Instrumentation and Evaluation of District 10 Caltrans Automated Warning System (CAWS)

Executive Summary

There is significant interest by traffic management personnel in the use of automated warning systems to provide drivers with real-time information on hazardous conditions related to traffic, limited visibility or roadway obstructions. In this work, we evaluate a large-scale real-time driver warning system, the Caltrans Automated Warning System (CAWS), located on the southbound direction of Interstate 5 and westbound direction of State Route 120 as they approach the junction near the San Joaquin River in Stockton, California. The CAWS covers 15 miles in an area known for dense recurrent fog, particularly at peak commute hours. It entered service in November 1996. The system includes 35 traffic speed monitoring sites, nine remote meteorological stations, and nine changeable message signs (CMS) for warning drivers. It is controlled by three computers located in the Caltrans District 10 Transportation Management Center. This system is believed to be one of the most advanced of its kind in the world.

We assessed the response of drivers to CAWS warning messages by measurement of traffic parameters on an individual vehicle basis at locations before and after the first CMS of the CAWS on southbound I-5. Over a two-year period of study, the speed, length and time of detection were recorded for every vehicle at four detection sites: two upstream and two downstream of the CMS. Visibility sensors before and after the CMS quantified local visibility, and surveillance cameras monitored both the traffic conditions and the actual message displayed by the CMS. Approximately 30 million vehicles were logged at each site over the two-year study period. During each fog or traffic event in which the CMS was activated, we examined mean speed, speed variance and potential collision speed (PCS). PCS considers the following distance, the visibility distance and speed of each vehicle to predict the impact speed if it had to brake abruptly, such as to avoid involvement in a multi-car collision in fog.

The challenge in this analysis was to separate the natural tendency of drivers to slow down in fog, as well as any site geometry effects, from the incremental affect of the CMS message. There appeared to be a consistent average incremental speed reduction of 1.1 mph and an average increase in PCS of 8.0 mph attributable to the CAWS warning message. Speed variance as measured by the standard deviation of the speeds of proximate vehicles was insignificantly affected by visibility reductions or the CAWS warnings.

A microscopic analysis of each fog event revealed two effects which explain the increase in PCS with a decrease in mean speed: (1) A subset of drivers comply to some degree with the advisory speed message. They build more densely-packed platoons behind them, with generally reduced gaps. (2) Since PCS is based on the minimum of the following distance or the visibility distance, if visibility gets worse, PCS increases unless there is a commensurate decrease in speed. The small average reduction in mean speed is actually comparable with results for similar systems. The CAWS results were not expected to be as great as, for example, the 5-6 mph reduction reported for the Dutch DRIVE system's dynamic speed limits that were enforced. The CAWS only advises safe speeds for the conditions.

Despite warning messages, it is disturbing to note that during fog event events, drivers continue at mean speeds consistently above 60 mph even in visibilities below 100 ft. Mean speeds in visibility as poor as 700 feet do not vary from speeds under clear conditions, typically 69-71 mph over all lanes, and 74-76

mph in lane 1. In fog, PCS values between 45 and 60 mph were typical, whereas PCS values during moderate traffic averaged 20-30 mph. It would require a degree of driver compliance beyond that achieved by *any* warning system we are aware of to prevent multi-car chain collisions in dense fog. All that can be achieved is small mean speed reductions that hopefully improve the odds. This is not a weakness unique to the CAWS.

We observed a number unexpected responses of the CAWS system which lead us to discover a number of operational problems related to software or control algorithm design issues. The response time between the visibility or trigger event and the corresponding CMS warning message was particularly problematic, with an average delay of over 7 minutes for fog messages, and between 3 and 6 minutes for traffic warning messages. The complexity of the system, and its vulnerability to single points of failure, made it a challenge to maintain. The system includes 210 inductive loop detectors, and 72 precision weather instruments, communicating over 45 individual telecom circuits. Collectively these factors may have contributed to a reduction in driver confidence in the CAWS. But an awareness of these issues suggests that with minor improvements, the CAWS could be more effective.

The results of analysis of collision data were mixed. Based on both raw and all normalizations of the data, encompassing all weather conditions, traffic levels, and collision classes, we found the CAWS associated with increased rates of collision during the first five years, but an improvement trend after 2001. Over the entire period 1997-2003 compared with the period 1992-1996, an average increase in travel-normalized collisions of 60% was observed in the study area, compared with 30% in a control area of identical traffic volume and geometry, and 25% and 62% respectively in adjoining areas with somewhat higher daily traffic volumes. Results for targeted accident such as collision in fog, rear-end collisions, or secondary collisions ran more generally negative. However, for a few targeted classes of collisions such as secondary collisions in fog, a positive effect may be evident. Effects of unusual roadway conditions and construction did not significantly change these results. However, when we fitted data in the CAWS and all three comparison areas to a multivariate generalized linear regression mode, we achieved predictions of a possible reduction of 15% in overall collisions, and 12% in fatal and injury collisions. Regarding the single question, “Based on collision data of all types, did the CAWS appear to be associated with an improvement in traffic safety?” we and our expert advisory panel feel that the overall results are inconclusive. Valuable localized and collision type-specific conclusions were generated, however. In particular, the junction of I-5 and SR-120 was clearly a problem area, while SR-120 and I-5 north of SR-120 fared better. It is probably reasonable to infer from the mix of results a net positive overall benefit attributable to the CAWS, but of unknown magnitude.

Considering the results of all evaluation tasks together, the evaluators are of the opinion that the CAWS does provide a positive safety benefit, to a degree consistent with or slightly less than reasonable expectations as established by similar systems in the USA or Europe. With minor modifications, its potential may be greater than previously demonstrated. In addition, we feel that the system has demonstrated an intrinsic value in traffic management and driver support that may transcend its immediately measurable or inferred effects on traffic safety.